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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04M — A2

(11) International Publication Number: **WO 00/69148**

(43) International Publication Date: 16 November 2000 (16.11.00)

(21) International Application Number: PCT/IL00/00229

(22) International Filing Date: 18 April 2000 (18.04.00)

(30) Priority Data:
09/309,906 11 May 1999 (11.05.99) US

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(81) Designated States: AE, AG, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, DZ, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

Without international search report and to be republished upon receipt of that report.

(54) Title: TELECOMMUNICATIONS SYSTEM FAILURE RECOVERY

(57) Abstract

A telephony system including a data network, a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, at least two telephony switches including a first telephony switch and a second telephony switch, each of the at least two telephony switches being operatively associated with the data network and operative to fulfill telephony service requests received via the data network in accordance with the telephony protocol and each including a system information database, the system information database being operative to store configuration information defining a plurality of characteristics of each of the telephony devices. The first telephony switch includes a first data replication subsystem operative to replicate the stored configuration information to the system information database included in the second telephony switch. Related apparatus and methods are also provided.

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TELECOMMUNICATIONS SYSTEM FAILURE RECOVERY

FIELD OF THE INVENTION

The present invention relates to telephony systems, and in particular to apparatus and methods for providing recovery from failures in telephony systems.

BACKGROUND OF THE INVENTION

Telephony switches are well known in the art. Typical prior art telephony switches which might be used on private premises, as opposed to being used as part of the public switched telephone network (PSTN), include switches available from Lucent Technologies and the AS5300 switch available from Cisco. Telephony switches are generally used to provide telephony services to end units such as conventional telephones, the services typically including basic services such as call establishment, routing of calls to other switches or to the PSTN, and other well known services. Advanced services may also be included, as is well known in the art.

One example of a prior art protocol which can be used in a telephony system including telephone switches is the H.323 v. 2 protocol of the International Telecommunications Union (ITU), published in 1998.

The problem of failure of a telephony system component, such as a telephony switch, is well known in the art. When a switch fails, various problems typically occur, including: inability of the switch to receive calls; loss of existing calls; inability of establishing new calls; long failure periods; and inability to recover in case of a site disaster.

Existing solutions to the problem of switch failure are typically based on the use of a

a shadow switch, including a backup switch which shadows ongoing operations and, at the time of failure, takes over for the failed switch. Generally, shadow machines are limited by a maximum physical distance from the master machine. In a case where a shadow machine is limited to be at the same physical location as the main machine, the shadow machine may also become inoperative in the case of a physical disaster. Generally, failure detection and recovery time for prior art shadow based systems is approximately 10 minutes.

Technologies related to those of the present invention are described in a co-pending application entitled "System for Building a Telephony Application", filed on the same day as the present application, having the same inventors and assigned to the same assignee as the present application. The "System for Building a Telephony Application" application is hereby incorporated herein by reference.

The disclosures of all references mentioned above and throughout the present specification are hereby incorporated herein by reference.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved telephony system. In one preferred embodiment of the present invention, an improved telephony system including an improved telephony switch is provided. In another preferred embodiment, the telephony switch may be provided alone.

In the present invention, a disaster recover mechanism which does not require the use of redundant shadow machines is provided. In the present invention, one switch uses peer-to-peer communication, as is well known in the art, to redundantly store important system information relating to the one switch on another active switch. In case of a failure of the first switch, operation is moved to the second switch, using the redundant stored information in the second switch or in another appropriate location. Preferably, failures are detected using a keep-alive system.

There is thus provided in accordance with a preferred embodiment of the present invention a telephony system including a data network, a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, at least two telephony switches including a first telephony switch and a second telephony switch, each of the at least two telephony switches being operatively associated with the data network and operative to fulfill telephony service requests received via the data network in accordance with the telephony protocol and each including a system information database, the system information database being operative to store configuration information defining a plurality of characteristics of each of the telephony devices, wherein the first telephony switch includes a first data replication subsystem operative to replicate the stored configuration information to the system

information database included in the second telephony switch.

Further in accordance with a preferred embodiment of the present invention the second telephony switch includes a second data replication subsystem operative to replicate the stored configuration information to the system information database included in the first telephony switch.

Still further in accordance with a preferred embodiment of the present invention the at least two telephony switches also includes a third telephony switch, and the second telephony switch includes a second data replication subsystem operative to replicate the stored configuration information to the system information database included in the third telephony switch.

Additionally in accordance with a preferred embodiment of the present invention the telephony protocol includes H.323.

There is also provided in accordance with another preferred embodiment of the present invention a telephony switch for use in a telephony system including a data network and a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, the telephony switch including a network adapter operative to provide communications via a data network between the telephony switch and a plurality of telephony devices and to receive telephony service requests from the telephony devices, a system information database, the system information database being operative to store configuration information defining a plurality of characteristics of each of the telephony devices, and a first data replication subsystem operative to replicate the stored configuration information to a second system information database external to the telephony switch.

Further in accordance with a preferred embodiment of the present invention the second system information database external to the telephony switch is included in a second telephony switch.

Still further in accordance with a preferred embodiment of the present invention the telephony protocol includes H.323.

There is also provided in accordance with another preferred embodiment of the present invention a method for providing recovery in a telephony system after the failure of a telephony switch included in the system, the method including providing a first telephony switch having an internal switch database for storing information and replication capability to replicate the stored information in another database external to the telephony switch, operating the first telephony switch, including storing system information in the internal switch database, replicating the stored system information to an external database external to the first telephony switch, detecting failure of the first telephony switch, in response to a result of the detecting step, failing over operations of the first telephony switch to a second telephony switch, using replicated system information in the external database.

Further in accordance with a preferred embodiment of the present invention the second telephony switch is selected based, at least in part, on a load of the second telephony switch, from a plurality of available telephony switches.

Still further in accordance with a preferred embodiment of the present invention the method also includes performing load balancing between the second telephony switch and at least one other telephony switch.

Additionally in accordance with a preferred embodiment of the present invention the step of detecting failure includes detecting failure using a keep-alive count.

Moreover in accordance with a preferred embodiment of the present invention the external database is included in the second telephony switch.

There is also provided in accordance with another preferred embodiment of the present invention a method for use in a telephony system including a data network and a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, the method including providing communications via a data network between a telephony switch and a plurality of telephony devices and receiving telephony service requests from the telephony devices, storing configuration information defining a plurality of characteristics of each of the telephony devices, and replicating the stored configuration information to a backup system information database.

Further in accordance with a preferred embodiment of the present invention the storing step includes storing in a system information database included in a first telephony switch.

Still further in accordance with a preferred embodiment of the present invention the backup system information database is included in a second telephony switch.

Additionally in accordance with a preferred embodiment of the present invention the telephony protocol includes H.323.

There is also provided in accordance with another preferred embodiment of the present invention, in a telephony system operative to provide failover of a telephony switch upon failure of the telephony switch to update a keep-alive count, a load balancing method comprising providing a plurality of telephony switches, identifying one of the plurality of telephony switches as an overloaded telephony switch, and

failing to respond to at least one keep-alive message directed to the overloaded telephony switch, thus causing at least one device associated with the overloaded telephony switch to fail over to another one of the plurality of telephony switches.

Further in accordance with a preferred embodiment of the present invention the method also includes determining whether a sufficient number of devices have failed over, and responding to at least one keep-alive message based, at least in part, on a result of the determining step.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified partly pictorial, partly block diagram illustration of a telephony system having failure recover characteristics, the system being constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified flowchart illustration of a preferred method of operation of the apparatus of Fig. 1;

Fig. 3 is a simplified flowchart illustration of a preferred load balancing method of operation of the apparatus of Fig. 1; and

Fig. 4 is a simplified block diagram illustration of a preferred implementation of a portion of the apparatus of Fig. 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1 which is a simplified partly pictorial, partly block diagram illustration of a telephony system having failure recovery characteristics, the system being constructed and operative in accordance with a preferred embodiment of the present invention. The system of Fig. 1 preferably comprises a plurality of telephony switches 100, comprising at least a first switch 110 and a second switch 120.

It is appreciated that a larger number of telephony switches 100 may be provided, only two telephony switches 100 being shown in Fig. 100 for sake of simplicity of description. Furthermore, it is appreciated that an alternative preferred embodiment of the present invention comprises a subcombination of the system of Fig. 1 comprising a single telephony switch 100, typically without the additional components shown in the system of Fig. 1.

The system of Fig. 1 also preferably comprises a data network 130, which may comprise any appropriate data network as is well known in the art, such as, for example, a LAN or a WAN.

The system of Fig. 1 also preferably comprises a plurality of telephony devices 140: a preferred implementation of the telephony devices 140 is described below with reference to Fig. 4. Each of the telephony devices 140 is preferably operatively associated with a plurality of end units 150 such as conventional telephones or other communication devices. It is appreciated that a wide variety of appropriate telephony devices 140 and end units 150. including telephony devices and end units which are well known in the art. may be used. It is further appreciated that other types of telephony device 140, including devices associated only with a single end unit or

themselves comprising an end unit, may be used.

The system of Fig. 1 also preferably comprises a gateway 155, typically comprising any appropriate gateway, as is well known in the art, operative to connect the remainder of the system of Fig. 1 to the public switched telephone network (PSTN) 160 or to another outside telephone network. Preferably, the gateway 155 also has failover capabilities similar to those described below with reference to the telephony switch 100.

Each telephony switch 100 preferably comprises, in addition to conventional components well known in the art of telephone switches, the following elements, typically in operative association with each other and with the conventional components:

1. a network adapter 170, the network adapter 170 being preferably operative to mediate bi-directional communications between the telephony switch 100 and the network 130;

2. a system information database 180, typically implemented in a combination of computer hardware and software as is well known in the art and preferably comprising an appropriate commercially available database management system, such as, for example: Oracle v. 8, commercially available from Oracle Corporation World Headquarters, 500 Oracle Parkway, Redwood Shores, CA 94065 USA.

3. a replication subsystem 190, typically implemented in software and preferably being operative to replicate, as is well known in the field of database management systems, at least a portion of the system information database 180 to a different database not comprised in the same telephony switch 100 as the replication subsystem 190. The replication subsystem 190 may comprise suitable commercially available

software, typically supplied together with a commercially available database management system. as mentioned above with reference to the system information database 180; typically the commercially available software is include in a commercially available database management system, as described above.

It is appreciated that various components of the system of Fig. 1, including each telephony switch 100 and each telephony device 140, may be implemented in a suitable combination of hardware and software, as is well known in the art. It is further appreciated that one or more of the plurality of telephony switches 100 comprised in the system of Fig. 1 may comprise conventional telephony switches (not shown), which conventional switches may not comprise at least unit 190 of the telephony switches 100 shown in Fig. 1.

The operation of the system of Fig. 1 is now briefly described. The first telephony switch 110 and the second telephony switch 120 each operate, similarly to conventional telephone switches, to provide telephony services in response to telephony service requests received via the network 130 from one or more of the end units 140. During provision of these services, each of the first telephony switch 110 and the second telephony switch 120 stores in the respective system information database 180 comprised therein information regarding the end units 140.

Typically the stored information comprises identification and configuration information sufficient to maintain connection with and provide services to the end units 140; additional information may also be stored. When information, predetermined to be a type of information important for maintaining service in the even of component failure, is stored in the system information database 180, the replication subsystem 190 replicates the stored information to another external

database. For example, when information is stored in the system information database 180 of the first switch 110 concerning end units 200 serviced by the first switch 110, the information may preferably be replicated to the system information database 180 of the second switch 120.

The case of storing in a database comprised in the second switch 120 is by way of example only, and is not meant to limit the generality of the foregoing.

Upon failure of the first switch 110, operations may thus be easily continued by the second switch 120. Any appropriate method may be used to determine that the first switch 110 has failed such as, for example, a keep alive method as is well known in the art.

Upon failure to update keep alive, either spontaneously by the first switch 110 or by failure to respond to a message from another component of the system such as an end unit 140 or the second switch 120, the other component of the system which detects the failure to update keep-alive preferably initiates fail-over to the second switch 120. Alternatively, a component which detects failure to update keep-alive may notify another component which initiates fail-over to the second switch 120. It will be appreciated that an appropriate choice of keep alive parameters may thus allow rapid failover in the system of Fig. 1.

Reference is now made to Fig. 2, which is a simplified flowchart illustration of a preferred method of operation of the system of Fig. 1. The method of Fig. 2 preferably comprises the following steps:

A switch is operated normally, preferably in a manner similar to that of prior art switches: during operation, system information is stored in an internal switch database (step 210). During normal operation as described in step 210, stored data in the

internal switch database is replicated to another database external to the switch, typically a database in another switch (step 220). Upon loss of keep-alive update or upon another appropriate indication of failure of the switch which has been replicating stored data, switch operations are failed over to another switch, using replicated data in the other database to continue operations (step 230).

Referring back to Fig. 1, it is appreciated that the apparatus of Fig. 1 may also perform load balancing as is well known in the art. In the present invention, a particular type of load balancing is possible in that an overloaded switch, such as a switch which receives connection of a plurality of devices upon failure of another switch, may cause load balancing to occur by failing to respond to keep-alive messages for a period of time, such as a predetermined period of time or until load on the overloaded switch drops to a predetermined load. Preferably, devices become attached to other switches according to the load of the switch to which attachment is made: this may also be true in the method of Fig. 2, in that failover may occur to the least loaded switch.

Reference is now made to Fig. 3, which is a simplified flowchart illustration of a preferred load balancing method of operation of the system of Fig. 1. The method of Fig. 3 is self-explanatory in light of the above explanation.

Reference is now made to Fig. 4, which is a simplified block diagram illustration of a preferred implementation of any of the telephony devices 140 of Fig. 1. The components of the apparatus of Fig. 4 may be implemented in any suitable combination of hardware and software, as is well known in the art.

The apparatus of Fig. 4 preferably comprises a digitized voice unit 240 and an audio packetizer 250 operatively associated therewith. The digitized voice unit 240 is

preferably operative to receive and send audio from and to an associated end unit such as any one or more of the end units 150 of Fig. 1 on one side; to digitize the audio if necessary: and to forward the digitized audio to or receive digitized audio from the audio packetizer 250. The audio packetizer 250 is preferably operative to packetize received digitized audio and to send the packetized digitized audio over a network such as the data network 130 of Fig. 1. The audio packetizer 250 is also preferably operative to receive packets from the network and to deliver digitized audio to the digitized voice unit 240.

The apparatus of Fig. 4 also preferably comprises the following components:

- telephony signaling apparatus 260;
- a state machine 270;
- an interface and failover layer 280; and
- an H.323 stack 290.

Preferably, the telephony signaling apparatus 260 is operatively associated with the state machine 270, which is operatively associated with the interface and failover layer 280, which is operatively associated with the H.323 stack 290, which is operatively associated with a network such as the data network 130 of Fig. 1. The units 260, 270, 280, and 290 preferably each operate bi-directionally, similarly to the digitized voice unit 240 and the audio packetizer 250 as previously explained. For the sake of simplicity of description only and without limiting the generality of the present invention, the units 260, 270, 280, and 290 will be described below as if they operated uni-directionally.

Telephony signaling apparatus 260 is preferably operative to receive telephony signals, as are well known in the art, from the end unit associated therewith and to

report the received signals to the state machine 270. The state machine 270 is preferably operative to track calls and telephony states. The interface and failover layer 280 is preferably operative to provide the state machine 270 with a convenient interface to the H.323 stack 290, and is responsible for connecting calls to a switch, such as the first telephony switch 110 of Fig. 1. Preferably, failover functions of the telephony device 140, as described above with reference to Figs. 1 - 3, are implemented in the interface and failover layer 280, said implementation being self-explanatory with reference to the above discussion of Fig. 1 - 3.

The H.323 stack 290 preferably comprises any appropriate standard H.323 stack, as is well known in the art, the H.323 stack 290 being operatively associated with the network.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable subcombination.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the invention is defined only by the claims which follow:

What is claimed is:

CLAIMS

1. A telephony system comprising:

a data network:

a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol;

at least two telephony switches comprising a first telephony switch and a second telephony switch, each of said at least two telephony switches being operatively associated with the data network and operative to fulfill telephony service requests received via the data network in accordance with the telephony protocol and each comprising:

a system information database, the system information database being operative to store configuration information defining a plurality of characteristics of each of said telephony devices, wherein

said first telephony switch comprises a first data replication subsystem operative to replicate the stored configuration information to the system information database comprised in said second telephony switch.

2. Apparatus according to claim 1 and wherein said second telephony switch comprises a second data replication subsystem operative to replicate the stored configuration information to the system information database comprised in said first telephony switch.

3. Apparatus according to claim 1 and wherein said at least two telephony switches also comprises a third telephony switch, and

said second telephony switch comprises a second data replication subsystem operative to replicate the stored configuration information to the system information database comprised in said third telephony switch.

4. Apparatus according to claim 1 and wherein said telephony protocol comprises H.323.

5. A telephony switch for use in a telephony system comprising a data network and a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, said telephony switch comprising:

a network adapter operative to provide communications via a data network between said telephony switch and a plurality of telephony devices and to receive telephony service requests from said telephony devices;

a system information database, the system information database being operative to store configuration information defining a plurality of characteristics of each of said telephony devices; and

a first data replication subsystem operative to replicate the stored configuration information to a second system information database external to said telephony switch.

6. Apparatus according to claim 5 and wherein said second system information

database external to said telephony switch is comprised in a second telephony switch.

7. Apparatus according to claim 5 and wherein said telephony protocol comprises H.323.

8. A method for providing recovery in a telephony system after the failure of a telephony switch comprised in the system, the method comprising:

providing a first telephony switch having an internal switch database for storing information and replication capability to replicate the stored information in another database external to the telephony switch;

operating the first telephony switch, including storing system information in the internal switch database;

replicating the stored system information to an external database external to the first telephony switch;

detecting failure of the first telephony switch;

in response to a result of the detecting step, failing over operations of the first telephony switch to a second telephony switch, using replicated system information in the external database.

9. A method according to claim 8 and wherein said second telephony switch is selected based, at least in part, on a load of said second telephony switch, from a plurality of available telephony switches.

10. A method according to claim 8 and also comprising:

performing load balancing between the second telephony switch and at least one other telephony switch.

11. A method according to claim 8 and wherein the step of detecting failure comprises detecting failure using a keep-alive count.

12. A method according to claim 8 and wherein the external database is comprised in the second telephony switch.

13. A method for use in a telephony system comprising a data network and a plurality of telephony devices each operatively associated with the data network and operative to request telephony services, via the data network, in accordance with a telephony protocol, said method comprising:

providing communications via a data network between a telephony switch and a plurality of telephony devices and receiving telephony service requests from said telephony devices;

storing configuration information defining a plurality of characteristics of each of said telephony devices; and

replicating the stored configuration information to a backup system information database.

14. A method according to claim 13 and wherein said storing step comprises storing in a system information database comprised in a first telephony switch.

15. A method according to claim 14 and wherein said backup system information

database is comprised in a second telephony switch.

16. A method according to claim 13 and wherein said telephony protocol comprises H.323.

17. In a telephony system operative to provide failover of a telephony switch upon failure of the telephony switch to update a keep-alive count, a load balancing method comprising:

providing a plurality of telephony switches;

identifying one of the plurality of telephony switches as an overloaded telephony switch; and

failing to respond to at least one keep-alive message directed to the overloaded telephony switch, thus causing at least one device associated with the overloaded telephony switch to fail over to another one of the plurality of telephony switches.

18. A method according to claim 17 and also comprising:

determining whether a sufficient number of devices have failed over; and

responding to at least one keep-alive message based, at least in part, on a result of the determining step.

FIG. 1

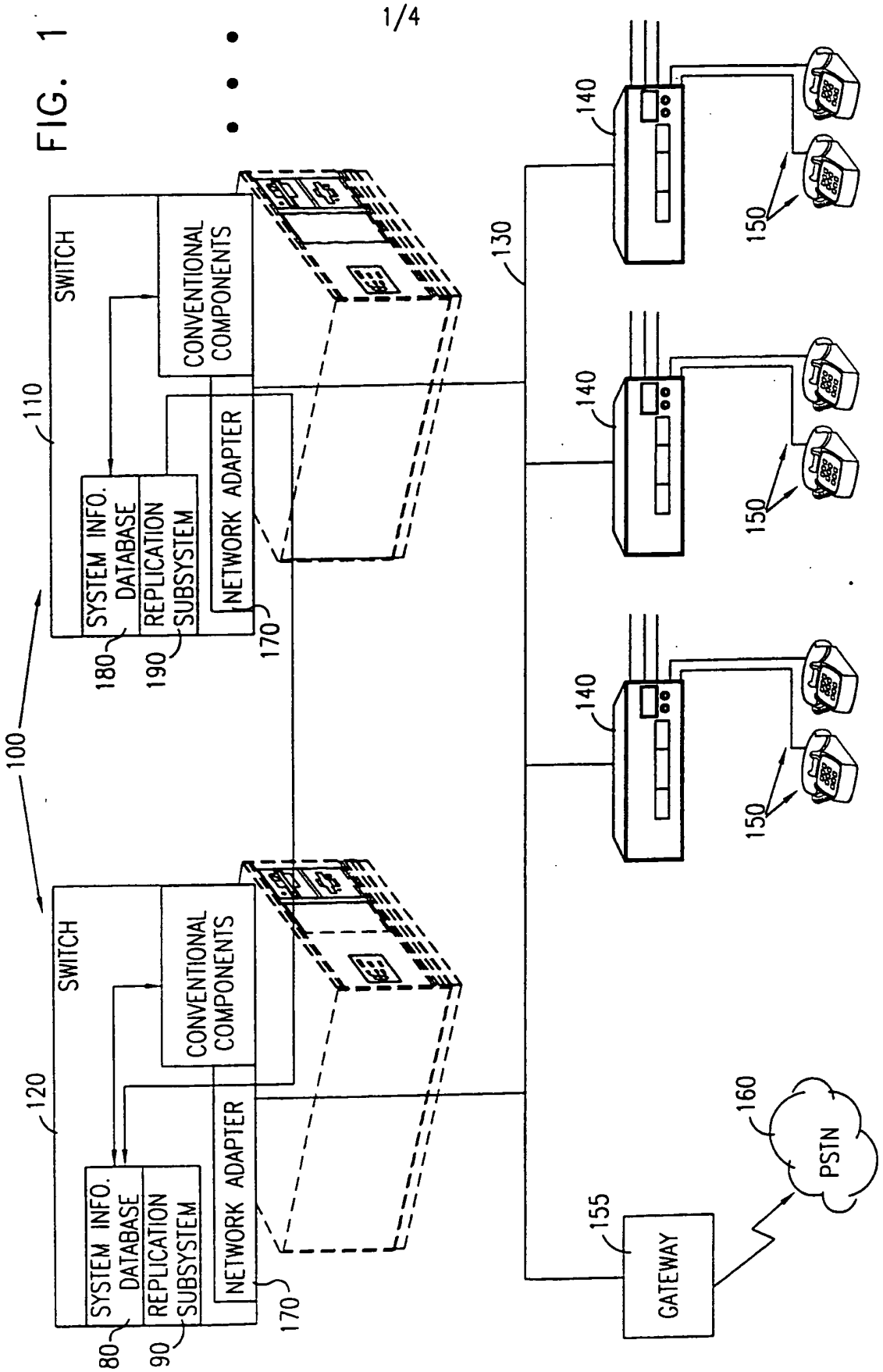

100
110
120
130
140
150
155
160
170
180
190
SWITCH
CONVENTIONAL COMPONENTS
SYSTEM INFO. DATABASE
REPLICATION SUBSYSTEM
NETWORK ADAPTER
GATEWAY
PSTN

FIG. 2

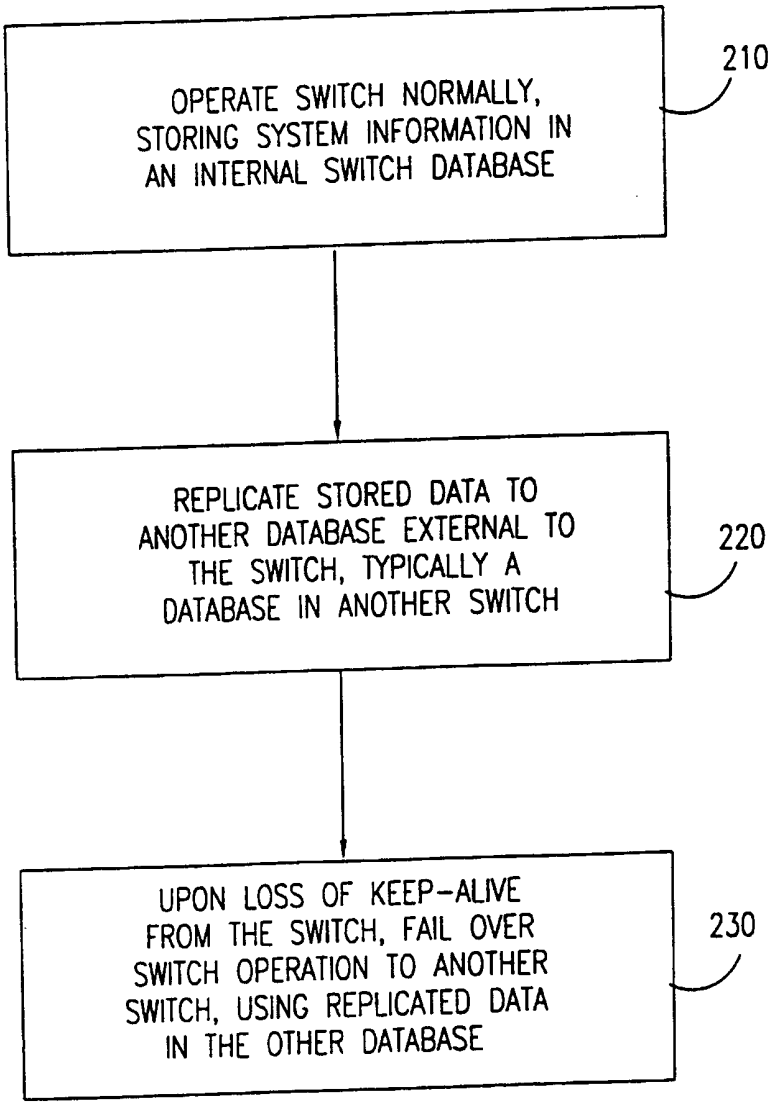

OPERATE SWITCH NORMALLY, STORING SYSTEM INFORMATION IN AN INTERNAL SWITCH DATABASE
210
REPLICATE STORED DATA TO ANOTHER DATABASE EXTERNAL TO THE SWITCH, TYPICALLY A DATABASE IN ANOTHER SWITCH
220
UPON LOSS OF KEEP-ALIVE FROM THE SWITCH, FAIL OVER SWITCH OPERATION TO ANOTHER SWITCH, USING REPLICATED DATA IN THE OTHER DATABASE
230

FIG. 3

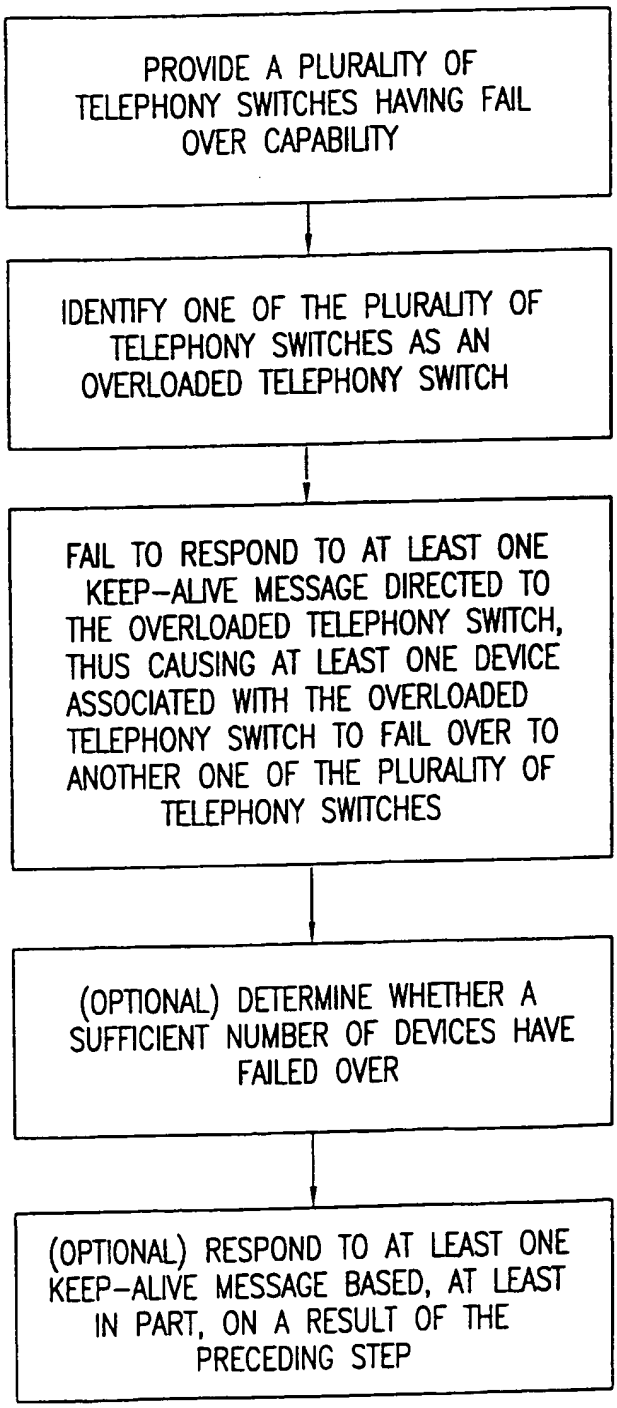
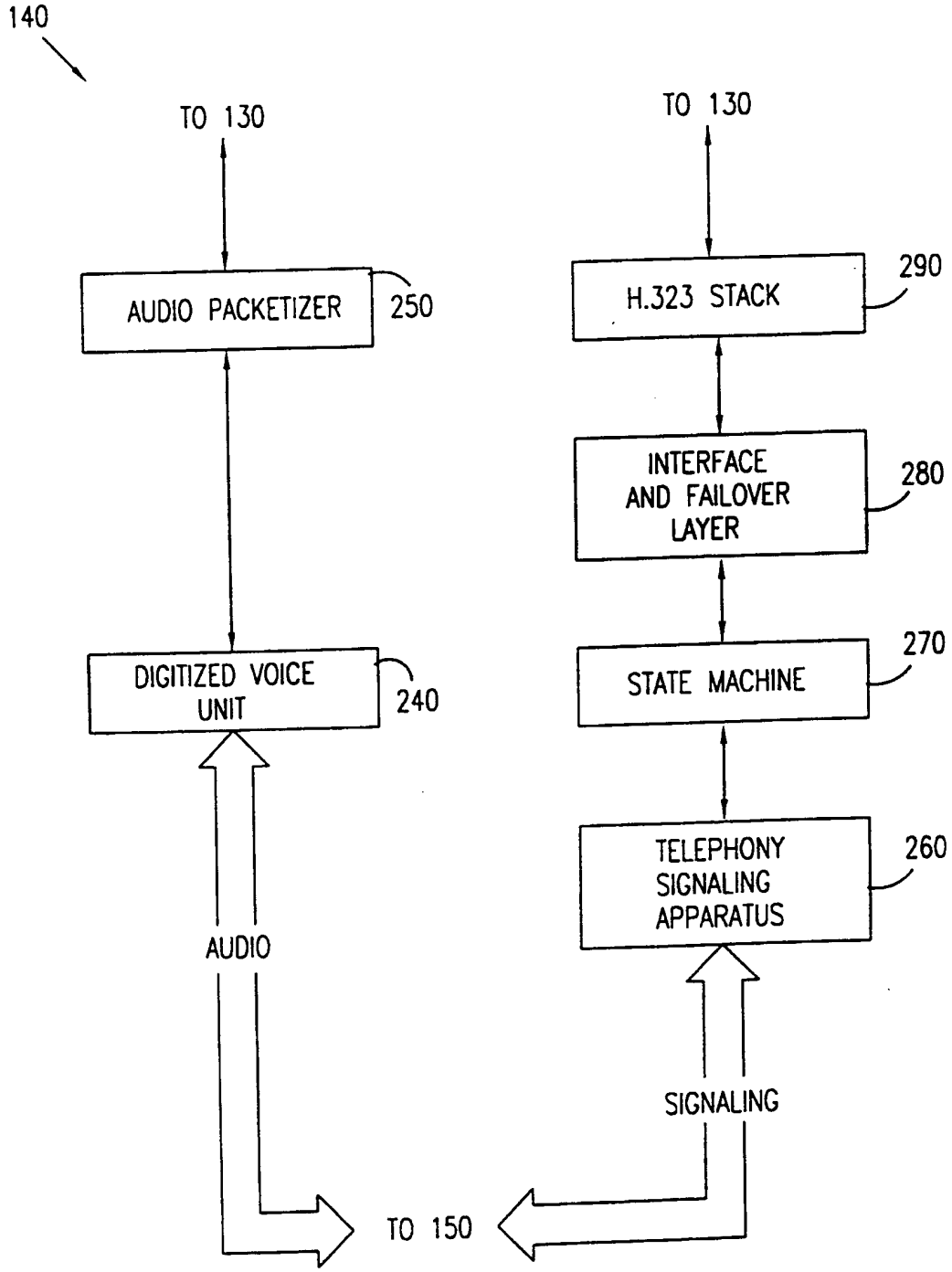

PROVIDE A PLURALITY OF TELEPHONY SWITCHES HAVING FAIL OVER CAPABILITY
IDENTIFY ONE OF THE PLURALITY OF TELEPHONY SWITCHES AS AN OVERLOADED TELEPHONY SWITCH
FAIL TO RESPOND TO AT LEAST ONE KEEP-ALIVE MESSAGE DIRECTED TO THE OVERLOADED TELEPHONY SWITCH, THUS CAUSING AT LEAST ONE DEVICE ASSOCIATED WITH THE OVERLOADED TELEPHONY SWITCH TO FAIL OVER TO ANOTHER ONE OF THE PLURALITY OF TELEPHONY SWITCHES
(OPTIONAL) DETERMINE WHETHER A SUFFICIENT NUMBER OF DEVICES HAVE FAILED OVER
(OPTIONAL) RESPOND TO AT LEAST ONE KEEP-ALIVE MESSAGE BASED, AT LEAST IN PART, ON A RESULT OF THE PRECEDING STEP

FIG. 4


140
TO 130
AUDIO PACKETIZER
250
DIGITIZED VOICE UNIT
240
AUDIO
TO 130
H.323 STACK
290
INTERFACE AND FAILOVER LAYER
280
STATE MACHINE
270
TELEPHONY SIGNALING APPARATUS
260
SIGNALING
TO 150